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Production potential and quality of fodder maize (*Zea mays*) varieties under varying intercropping systems with cowpea *(Vigna unguiculata*)

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Abstract
An investigation was conducted during the *zaid* seasons of 2013-14 and 2014-15. Three fodder maize cultivars 'African tall, J-1006 and local variety' and cowpea 'CL-367' were sown as sole crop as well as in intercropping systems consisting 16 treatments which were laid down in RBD. The results revealed that among the intercropping treatments, African tall intercropped with cowpea in 2:1 ratio recorded significantly highest green biomass yield which was found at par with African tall intercropped with cowpea in 2:1 seed mix and J-1006 intercropped with cowpea in 2:1 ratio. Similarly, dry matter yield was also found to be significantly maximum with African tall intercropped with cowpea in 2:1 row ratio which was at par with same intercropping system in 1:1 row ratio. Significantly the highest crude protein yield was observed with African tall intercropped in 1:1 ratio. The highest crude fibre and NDF yields were recorded in local variety intercropped with cowpea in 2:1 row ratio whereas significantly the highest ADF was recorded with local variety intercropped with cowpea in 1:1 mix.

Keywords: Cowpea, Fodder quality, Fodder yield, Intercropping, Maize variety

Introduction

Forage production is the backbone of livestock industry in India. The scarcity of green forages and grazing resources in the country has made the livestock to suffer continuously with malnutrition resulting in their production potentiality at suboptimum level as compared to developed nations. The annual forage requirement of our country is 1650 million tonnes (1061 million tonnes green and 589 million tonnes dry). The present feed and fodder resources of the country can meet only 48 per cent of the requirement with a vast deficit of 62.7 and 23.4 per cent of green and dry fodder, respectively (Anonymous, 2010).

Intercropping of botanically diverse forage species like cereals and legumes appear to be one of the feasible approaches for increasing the herbage yield, utilization of land more efficiently, improving the forage quality and providing stability to production (Tripathi, 1989; Kumar *et al*., 2014). Maize (*Zea mays*), among the different fodder crops is regarded as one of the important dual purpose crop, used in human diet as well as animal feed. Maize has the potential to supply large amounts of energy-rich forage for daily animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid/ prussic acid toxicity as in case of sorghum (Dahmardeh *et al*., 2009). Thus forage maize has become a major constituent of ruminant rations in recent years, as its inclusion as dairy cow diets improves forage intake, increases animal performance and reduces production costs (Anil *et al*., 2000). Cowpea (*Vigna unguiculata*), an annual legume with high level of protein (about two times more than maize), can be mixed with maize to improve forage protein content of diets and thus, the cost of high quality forage production can be lowered. It provides an efficient utilization of environmental resources, reduces risk of the cost of production, provides greater financial stability for farmers, decreases pest damages, suppresses weed growth more than monocultures, improves soil fertility through increased N content and improves forage yield and quality (Francis *et al*., 1976; Willey, 1979). So, there is need to standardize the suitable maize variety intercropped with cowpea having preferable fodder quality and quantity in unit area of land to fulfill requirement of livestock feeds. Hence, this study was undertaken to determine the effect of intercrop (cowpea) on main crop (maize) and total herbage yield, and quality *vis-a-vis* economic viability of the system.

Materials and Methods

Crop growing conditions: A field experiment was conducted during the *zaid* seasons of 2013-14 and 2014-15 at Research Farm of Sher-e-Kashmir University

of Agricultural Sciences and Technology of Jammu, Main Campus, Chatha (32°40' N, 74°58' E; 320 m amsl). The analysis of the soil samples indicated that the soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction (pH 7.31), low in organic carbon (3.7 g kg^{-1}) and available nitrogen (245.78 kg ha^{-1}) but medium in available phosphorus (13.26 kg ha^{-1}) and potassium (144.26 kg ha^{-1}) with electrical conductivity (0.19 dS m^{-1}). The recommended dose of N: P_2O_5: K_2O for maize crop is 50:24:12 kg ha^{-1}. Half of the total dose of recommended nitrogen, full dose phosphorus and potash were applied at the time of sowing and the remaining half dose of nitrogen was applied at 25 days after sowing. Urea, DAP and MOP were used as source of N, P and K.

***Experimental design*:** The experiment was laid out in a randomized block design (RBD) with sixteen treatments replicated thrice. The treatments comprised three varieties of fodder maize *viz*., African tall, J-1006 and a local variety, and one variety of fodder cowpea (CL-367) raised sole and in intercropping systems with rows as well as seed mix ratio of 1:1 and 2:1.

***Plant sampling*:** For growth and developmental studies during the crop growth period, five plants were selected at random from the selected row of each net plot and tagged. Destructive plant sampling was done from the border rows of the plots where treatment was imposed. Stem girth was recorded at maximum diameter of the stem at harvest. On the basis of green forage yield per plot, treatment-wise green forage yield in quintal per ha was calculated. Samples drawn for dry matter accumulation studies at harvest were utilized for calculating dry matter yield (DMY). Fresh weight of samples were recorded and dried in hot air oven at 65 °C for 48-72 hours to record the dry weight. Plot-wise green forage yield was multiplied by respective dry matter percentage to get dry weight in kg per plot and was expressed in q ha^{-1}.

***Chemical analysis*:** The determination of different quality parameters was done as per AOAC (2005); however, fiber fractions [neutral detergent fiber (NDF) and acid detergent fiber (ADF)] were analyzed as per the method of Van Soest *et al.* (1991).

***Statistical analysis*:** The data recorded for various characters were subjected to statistical analysis according to procedure outlined by Cochran and Cox (1963).

Results and Discussion

Forage yields

***Growth characters*:** Among the intercropping treatments, highest plant height of 209.03 cm was recorded in African tall cultivar of fodder maize when intercropped with cowpea in 2:1 seed mix, whereas the lowest plant height of maize (175.48 cm) was recorded in local variety of fodder maize when intercropped with cowpea in 1:1 seed mix (Table 1).

Sole African tall cultivar recorded 14.76 numbers of leaves per plant and the lowest numbers of leaves (12.22) per plant were noticed with sole local variety. Sole cowpea recorded highest numbers of leaves/plant *i.e.* 55.82 as compared to the different intercropping treatments of cowpea. Similarly, among intercropping treatments the highest number of total leaves (13.99) of maize were observed in African tall intercropped with cowpea in 2:1 row ratio whereas the lowest number of leaves per plant (8.68) were seen in local variety intercropped with cowpea in 1:1 seed mix treatment (Table 1).

Maximum stem girth of fodder maize was recorded in sole African tall (7.72 cm) whereas in intercropping treatments, highest value of stem girth (6.58 cm) was recorded with African tall cultivar of maize intercropped with cowpea in 2:1 row ratio. Lowest stem girth (5.24 cm) of fodder maize was recorded in local variety of maize when intercropped with cowpea in 1:1 seed mix.

Fodder maize cultivar African tall intercropped with cowpea in 2:1 row ratio and 2:1 seed mix recorded higher plant height with higher number of leaves per plant and stem girth. This might be due to impact of competition between the two crops for the available resources in the field including space and nutrients whereas the difference in number of leaves per plant is due to the genetic makeup of the cultivar (Islam *et al.,* 2014).

***Yield attributes*:** Pooled data (Table 2) revealed that different sole fodder cultivars and intercropping treatments differed significantly from each other. African tall intercropped with cowpea in 2:1 ratio recorded significantly highest green biomass yield (293.84 q ha^{-1}) which was found at par with African tall intercropped with cowpea in 2:1 seed mix and J-1006 intercropped with cowpea in 2:1 ratio producing 285.00 and 279.64 q ha^{-1}. This might be due to more growth as indicated by its greater height. Similar results were also reported by Patil

et al. (1996) while studying the yielding ability of forage maize genotypes in mixed cropping with cowpea. However, lowest green biomass yield was observed with local variety intercropped with cowpea in 1:1 seed mix (224.56 q ha^{-1}) which remained statistically at par with the local variety intercropped with cowpea in 1:1 row ratio (236.80 q ha^{-1}).

Table 1. Influence of maize cultivars and cowpea intercropping systems on plant height, number of leaves and stem girth at harvest (mean of two years)

Treatments	Plant height (cm)		Number of leaves/plant		Stem girth (cm)	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
Sole African tall	230.08	-	14.76	-	7.72	-
Sole J-1006	213.77	-	12.96	-	7.27	-
Sole local variety	202.60	-	12.22	-	5.67	-
Sole cowpea var. CL-367	-	212.83	-	55.82	-	2.82
African tall + cowpea (1:1)	193.34	193.83	12.82	44.35	6.63	3.36
African tall + cowpea (2:1)	197.82	194.06	13.99	54.92	6.58	3.01
African tall + cowpea (1:1 mix)	188.67	196.90	12.77	42.76	5.56	3.12
African tall + cowpea (2:1 mix)	209.03	201.48	13.16	50.51	6.55	3.17
J-1006 + cowpea (1:1)	181.51	186.32	11.99	33.14	5.81	2.79
J-1006 + cowpea (2:1)	197.44	188.07	12.76	42.42	5.92	2.52
J-1006 + cowpea (1:1 mix)	184.49	201.89	11.58	37.01	5.79	2.76
J-1006 + cowpea (2:1 mix)	205.36	182.60	12.42	44.06	5.89	2.72
Local variety + cowpea (1:1)	180.99	171.95	8.84	41.50	5.33	2.67
Local variety + cowpea (2:1)	187.34	185.35	11.41	45.92	5.61	2.31
Local variety + cowpea (1:1 mix)	175.48	180.16	8.68	41.00	5.24	2.67
Local variety + cowpea (2:1 mix)	185.33	180.80	10.64	36.06	5.59	2.52

Table 2. Influence of maize cultivars and cowpea intercropping systems on green fodder and dry matter yield (mean of two years)

Treatments	Biomass yield (q ha^{-1})					
	Green			Dry		
	Maize	Cowpea	Total	Maize	Cowpea	Total
Sole African tall	211.93	-	211.93	48.36	-	48.36
Sole J-1006	205.90	-	205.90	46.35	-	46.35
Sole local variety	185.33	-	185.33	40.95	-	40.95
Sole cowpea var. CL-367	-	165.29	165.29	-	36.34	36.34
African tall + cowpea (1:1)	142.67	129.81	272.48	39.33	30.27	69.61
African tall + cowpea (2:1)	168.31	125.17	293.48	43.47	28.34	71.81
African tall + cowpea(1:1 mix)	138.70	126.19	264.89	34.64	29.22	63.86
African tall + cowpea (2:1 mix)	159.17	125.74	285.00	43.61	26.14	69.74
J-1006 + cowpea (1:1)	132.15	120.41	252.56	31.34	22.71	54.05
J-1006 + cowpea (2:1)	158.33	115.46	273.79	42.96	22.29	65.25
J-1006 + cowpea (1:1 mix)	132.32	117.00	249.31	30.29	22.80	53.09
J-1006 + cowpea (2:1 mix)	150.34	115.48	265.82	31.23	24.11	55.34
Local variety + cowpea (1:1)	131.80	105.00	236.80	28.52	17.82	46.35
Local variety + cowpea (2:1)	144.76	101.58	246.34	39.61	16.80	56.41
Local variety + cowpea (1:1 mix)	128.23	104.33	224.56	26.06	17.70	43.76
Local variety + cowpea (2:1 mix)	140.83	101.77	242.60	35.82	16.80	52.62
SEm (±)			5.24			3.18
LSD (P=0.05)			16.16			3.02

Among various intercropping treatments, significantly maximum dry matter yield (72.81 q ha^{-1}), was recorded with the African tall intercropped with cowpea in 2:1 row ratio which was at par with African tall intercropped with cowpea in 2:1 seed mix as well as 1:1 seed mix (69.74 and 69.61 q ha^{-1}). Various sole fodder maize cultivars and intercropping treatments increased the dry matter yield of crop up to harvest. Among fodder maize cultivars, African tall recorded highest dry biomass yield 48.36 q ha^{-1} at harvest which was followed by sole J-1006 (46.35 q ha^{-1}) and sole local variety (40.95 q ha^{-1}). Due to higher plant height and number of leaves in 2:1 as compared to 1:1 row ratio and 1:1 seed mix which contributed ultimately to higher yield along with the exploitation of different resources from various soil layers without competing with each other (Sharma *et al.,* 2008). Whereas dry matter of sole cowpea was recorded 36.34 q ha^{-1} which was lower to all fodder maize cultivars.

Quality parameters

Crude protein and crude fibre yield: Crude protein yield (Table 3) differed significantly among the different sole fodder cultivars and intercropping treatments. Significantly highest crude protein yield (949.60 kg ha^{-1}) was recorded with sole fodder cowpea. This was due to high crude protein content of legumes. Similar results were also reported by Nyamagouda and Angadi (2002), Sahoo *et al.* (2015) and Karforma *et al.* (2016) while studying the mixed seeding and quality of forage maize-legume mixed cropping system. Among sole fodder maize cultivars, African tall recorded maximum crude protein yield (283.76 kg ha^{-1}), but the values obtained with J-1006 and local variety were found at par statistically. Among different intercropping treatments the highest crude protein yield was recorded with African tall intercropped in 2:1 row ratio (751.10 kg ha^{-1}) which was at par with crude protein yield of 1:1 row ratio of the same treatment. Highest crude protein yield in African tall and cowpea intercropping might be due to result of fixation of higher amount of nitrogen and its release, either by direct excretion from legume root system with nodules or by decomposition of nodule and root debris (Prasanthi and Venkateswaralu, 2014).

Crude fibre yield (Table 3) differed significantly among the different sole fodder cultivars and intercropping treatments. Significantly highest crude fibre yield (1792.78 kg ha^{-1}) was recorded with sole fodder cowpea. Among sole fodder maize cultivars, African tall recorded maximum crude fibre yield (1505.51 kg ha^{-1}), which was statistically at par with sole J-1006 cultivar; however the local variety recorded the minimum value of crude fibre yield (968.82 kg ha^{-1}). In intercropping treatments, significantly highest crude fibre yield of 2277.32 kg ha^{-1} was recorded with local variety intercropped with cowpea in 2:1 row ratio whereas the lowest crude fibre yield of 1139.50 kg ha^{-1}

Table 3. Influence of maize cultivars and cowpea intercropping systems on crude fibre and crude protein yield (mean of two years)

Treatments	Crude protein yield (kg ha^{-1})			Crude fibre yield (kg ha^{-1})		
	Maize	Cowpea	Total	Maize	Cowpea	Total
Sole African tall	283.76	-	283.76	1505.51	-	1505.51
Sole J-1006	253.47	-	253.47	1367.35	-	1367.35
Sole local variety	193.76	-	193.76	968.82	-	968.82
Sole cowpea var. CL-367	-	949.60	949.60	-	1792.78	1792.78
African tall + cowpea (1:1)	261.50	486.82	748.32	692.00	535.07	1227.07
African tall + cowpea (2:1)	276.93	474.17	751.10	812.19	622.75	1434.94
African tall + cowpea (1:1 mix)	231.54	513.15	744.69	619.70	519.80	1139.50
African tall + cowpea (2:1 mix)	231.07	443.99	675.06	797.50	584.05	1381.55
J-1006 + cowpea (1:1)	227.07	457.67	684.74	880.81	700.69	1581.50
J-1006 + cowpea (2:1)	224.97	443.42	668.39	1007.69	722.54	1730.23
J-1006 + cowpea (1:1 mix)	179.74	487.49	667.23	861.03	695.15	1556.18
J-1006 + cowpea (2:1 mix)	162.83	423.44	586.27	926.52	706.80	1633.32
Local variety + cowpea (1:1)	177.82	390.15	567.97	1177.10	858.70	2035.80
Local variety + cowpea (2:1)	178.42	344.97	523.39	1204.32	1073.00	2277.32
Local variety + cowpea (1:1 mix)	140.64	387.05	527.69	1047.55	832.77	1880.32
Local variety + cowpea (2:1 mix)	150.14	321.50	471.64	1181.27	877.25	2058.52
SEm (±)	-	-	37.48	-	-	71.79
LSD (P=0.05)	-	-	109.08	-	-	207.25

was recorded with African tall intercropped with cowpea in 1:1 seed mix, respectively. Crude fibre yield showed declining trend with increase in nitrogen. The results could be attributed to the fact that higher nitrogen result in higher protein synthesis and lower soluble carbohydrates which could be responsible for lower crude fibre content of the fodder maize, which increase palatability and digestibility (Mahdi *et al.,* 2012).

Neutral detergent fibre (NDF) and Acid detergent fibre (ADF): Results indicated non-significant differences among the sole fodder cultivars for NDF yields (Table 4; Fig 1). Among the intercropping treatments highest NDF yield of 4488.0 kg ha^{-1} was recorded with local variety intercropped with cowpea in 2:1 seed mix whereas the lowest value of NDF yield of 2742.0 kg ha^{-1} was recorded in African tall intercropped with cowpea in 1:1 seed mix. Sole cowpea recorded acid detergent fibre value to the tune of 1385.02 kg ha^{-1}. Among the intercropping treatments, highest yield of ADF (2373 kg ha^{-1}) was recorded in local variety intercropped with cowpea in 2:1 seed mix and the lowest value of ADF yield (1824.0 kg ha^{-1}) was recorded in African tall intercropped with cowpea in 2:1 row ratio.

Table 4. Influence of maize cultivars and cowpea intercropping systems on neutral detergent fibre (NDF) and acid detergent fibre (ADF) yield (mean of two years)

Treatments	NDF yield (kg ha^{-1})			ADF yield (kg ha^{-1})		
	Maize	Cowpea	Total	Maize	Cowpea	Total
Sole African tall	2508.91	-	2508.55	1392.19	-	1392.19
Sole J-1006	3068.27	-	3068.27	1727.33	-	1727.33
Sole local variety	3086.36	-	3086.36	1739.54	-	1739.54
Sole cowpea var. CL-367	-	2128.10	2128.10	-	1385.02	1385.02
African tall + cowpea (1:1)	1947.00	842.00	2789.00	1172.00	705.00	1877.00
African tall + cowpea (2:1)	1714.00	971.00	2685.00	1195.00	629.00	1824.00
African tall + cowpea(1:1 mix)	1876.00	866.00	2742.00	1195.00	667.00	1862.00
African tall + cowpea(2:1 mix)	1934.00	1012.00	2946.00	1408.00	549.00	1957.00
J-1006 + cowpea (1:1)	2296.00	1088.00	3384.00	1616.00	476.00	2092.00
J-1006 + cowpea (2:1)	2044.00	1114.00	3158.00	1520.00	539.00	2059.00
J-1006 + cowpea (1:1 mix)	2162.00	1199.00	3361.00	1583.00	502.00	2085.00
J-1006 + cowpea (2:1 mix)	2217.92	1222.00	3439.92	1608.00	497.00	2105.00
Local variety + cowpea (1:1)	2800.00	1354.00	4154.00	1521.00	832.00	2353.00
Local variety + cowpea (2:1)	2740.00	1393.00	4133.00	1608.00	742.00	2350.00
Local variety + cowpea (1:1 mix)	2849.00	1293.00	4142.00	1616.00	736.00	2352.00
Local variety + cowpea (2:1 mix)	2813.00	1675.00	4488.00	1583.00	790.00	2373.00
SEm (±)	-	-	356.74	-	-	136.36
LSD(P=0.05)	-	-	1035.33	-	-	395.76

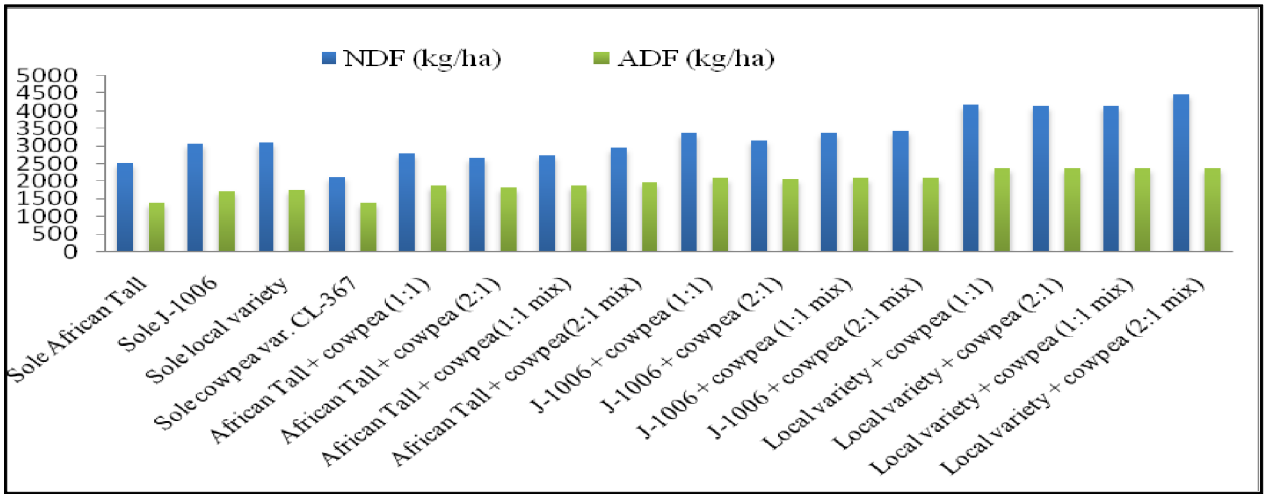

Fig 1. Influence of maize cultivars and cowpea intercropping systems on fibre yields (kg ha^{-1})

In fodder low percentage of ADF and NDF are desirable. Low ADF values mean that fodder has higher energy value and digestibility. Neutral digestible fibre of forage is inversely related to the amount of fodder that animal is able to consume. ADF and NDF yields were found highest in sole fodder maize local variety, while in the intercropping treatments ADF and NDF yields were found highest for local maize variety intercropped with cowpea in 2:1 row ratio. This might be due to intercropping of legumes with maize which caused significant reduction in ADF and NDF contents and ultimately in ADF and NDF yields (Eskandari *et al.,* 2009; Mut *et al*., 2017).

Conclusion

From two year experimentation it may be concluded that among the intercropping treatments, African tall intercropped with cowpea in 2:1 seed mix recorded higher plant height, while same in 2:1 row ratio recorded significantly highest number of leaves and green biomass yield which was at par with African tall intercropped with cowpea in 2:1 seed mix and J-1006 intercropped with cowpea in 2:1 ratio. Similarly, dry matter yield was also found significantly maximum in African tall intercropped with cowpea in 2:1 row ratio which was at par with the same intercropping system in 1:1 row ratio. Significantly highest crude protein yield was observed with African tall intercropped in 1:1 ratio. Highest crude fibre yield and NDF were recorded in local variety intercropped with cowpea in 2:1 row ratio whereas significantly highest ADF was recorded with local variety intercropped with cowpea in 1:1 mix.

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